National Toxicology Program
Toxicity Report Series
Number 58

NTP Technical Report
on Toxicity, Reproductive, and Developmental Studies of

60-Hz Magnetic Fields

Administered by Whole Body Exposure
to F344/N Rats, Sprague-Dawley Rats, and B6C3F$_1$ Mice

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United States Department of Health and Human Services
Public Health Service
National Institutes of Health

Note to the Reader

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- the National Cancer Institute (NCI) of the National Institutes of Health;
- the National Institute of Environmental Health Sciences (NIEHS) of the National Institutes of Health;
- the National Center for Toxicological Research (NCTR) of the Food and Drug Administration; and
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The studies described in this toxicity study report were performed under the direction of NIEHS and were conducted in compliance with NTP laboratory health and safety requirements. These studies met or exceeded all applicable federal, state, and local health and safety regulations. Animal care and use were in accord and compliance with the Public Health Service Policy on Humane Care and Use of Animals.

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This NTP report on the toxicity studies of 60-Hz magnetic fields is based primarily on 8-week toxicity studies that took place from September through October 1993 and the teratology and continuous breeding studies that took place from September 1993 through August 1994.

National Toxicology Program

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PEER REVIEW

The draft report on the toxicity studies of 60-Hz magnetic fields was evaluated by the reviewers listed below. These reviewers serve as independent scientists, not as representatives of any institution, company, or governmental agency. In this capacity, reviewers determine if the design and conditions of these NTP studies are appropriate and ensure that the toxicity study report presents the experimental results and conclusions fully and clearly.

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CONTENTS

ABSTRACT

Electric and magnetic fields are associated with the production, transmission, and use of electricity; thus the potential for human exposure is high. These electric and magnetic fields are predominantly of low frequency (60 Hz) and generally of low intensity. The prevailing view among physicists is that exposure to these low-frequency, low-intensity fields does not pose a health hazard. However, this view has been challenged by reports linking magnetic field exposure to the development of leukemia and other cancers. Because multiple epidemiologic studies suggested a potential for increased cancer rates with increasing exposure, and because of public concern, the effects of 60-Hz magnetic field exposure were examined in F344/N rats and B6C3F_1 mice in 8-week full-body-exposure studies. Animals were evaluated for hematology and clinical chemistry (rats only) parameters, pineal gland hormone concentrations, and histopathology. Additional studies were performed in Sprague-Dawley rats to examine teratologic and reproductive effects of magnetic field exposure.

In the 8-week toxicity studies, groups of male and female F344/N rats and B6C3F_1 mice were exposed for 18.5 hours per day to 60-Hz magnetic fields at intensities of 0 (control), 0.02, 2, and 10 gauss (G). Additional groups of rats and mice were exposed to intermittent 10 G fields (1 hour on/1 hour off) for 18.5 hours per day. No evidence of toxicity associated with exposure to magnetic fields was observed in rats or mice. Clinical observations provided no evidence of adverse effects associated with magnetic field exposure. Compared to control rats and mice, there were no biologically significant differences in hematology or clinical chemistry parameters of rats exposed to magnetic fields. No gross lesions or histopathologic findings in rats or mice were attributed to exposure to 60-Hz magnetic fields. In addition, magnetic field exposure was not associated with a significant reduction in serum melatonin or pineal gland melatonin concentration, or pineal gland activity of *N*-acetyltransferase in either species.

One female rat in the 2 G exposure group died during the 8-week toxicity study from causes unrelated to magnetic field exposure; all other male and female rats and mice in the study survived until the end of the study. Final mean body weights and mean organ weights of a few groups of exposed animals differed from those of the control groups; however, no clear pattern of magnetic field effects was observed, and these differences are not considered to be biologically significant.

For the teratology study, groups of 55 pregnant female Sprague-Dawley rats were exposed to the same magnetic fields as in the toxicity study on gestation days 6 through 19. Fifteen pregnant females exposed to 85 mg ethylenethiourea/kg body weight served as positive controls. Except for the positive controls, there were no changes in maternal or fetal weights, nor were fetal abnormalities found. The number of pregnant females was

significantly lower in groups exposed to magnetic fields than in the control group; however, all breeding in the teratology study was completed prior to the first day of magnetic field or sham exposure. On this basis, this finding is unrelated to magnetic field exposure. In addition, there were no differences between control and exposed groups in the number of pregnant females in the continuous breeding study, in which breeding took place within the magnetic fields.

Groups of 40 breeding pairs of Sprague-Dawley rats were exposed to the same magnetic fields as in the toxicity study during the breeding and lactation of five litters in a continuous breeding study. The fifth litter was exposed during gestation and lactation; one male and one female from each litter were raised to sexual maturity receiving the same exposures as the parents; rats were mated to nonsibling rats and allowed to deliver the third-generation offspring. The results of the continuous breeding study demonstrated no effects of magnetic field exposure on reproductive performance in either male or female rats.